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High-Level Nuclear Waste Disposal: Policy and Prognosis

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ABSTRACT

Solving the United States' high level nuclear waste disposal dilemma is vital to our energy independence and economic growth. The issue has been stalled for decades and presently faces enormous political obstacles despite renewed government effort to achieve a solution. Some technical questions persist, however the issue is mainly one of politics. The current course of action, in which the federal government is forcing a state to accept siting of the permanent waste repository, is flawed and politically deadlocked. A better plan would be one in which the region accepting the repository benefits and thus seeks to host, vice impede, its construction.

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NUCLEAR WASTE DISPOSAL: POLARIZATION AND STALEMATE

> "Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future." (Albert Einstein in a letter to President Franklin Roosevelt, August 2, 1939.) [1]

Since Dr. Einstein first called his President's attention to its possibilities, the debate over peaceful nuclear energy production has been tortuous, controversial and filled with emotion. As one of the highest profile issues of any on today's agenda, its ultimate resolution could have a major impact on this country's economic growth and prosperity for decades to come. Despite well-known failings and very real concerns, its proponents (many of whom are scientists and engineers) continue to point out its economic and environmental advantages -- reliable, less expensive than other energy sources, abundant, and recently, environmentally benign (compared with coal, its chief rival in electricity production).

Opponents are equally adamant that nuclear power must be halted due to safety concerns (Three Mile Island, Brown's Ferry, Chernobyl), its increasing cost, the deleterious effects of radiation on humans and the problem of what to do with the radioactive waste it generates.

While safety concerns have largely stopped new nuclear

plant construction in the U.S. since Three Mile Island (and 65 nuclear power plants already on order have been cancelled since then) the nuclear waste disposal issue is beginning to appear to be the one upon which nuclear energy's fate may be sealed. This is the context in which the disposal of high-level nuclear waste is examined in this paper. In the following paragraphs, the question of how best to dispose of the nation's spent nuclear fuel, which has been building up for decades at over 100 currently operational nuclear reactor plants, is addressed. The legal framework is described, the technical issues and the government's plan is detailed, and the economic, scientific, regulatory and political components of the debate are summarized.

One of the first impressions formed when a review of the high level nuclear waste disposal issue is begun is that the opposing factions have become entrenched and dogmatic in their attitude toward positions that differ from theirs. The fact that this can be said about even the highest levels of government is indicative of how little has been accomplished toward a resolution suitable to all parties. The author attempted to take the polarized views on nuclear waste disposal into account in the conduct of research for this paper. A brief summary of how high level nuclear waste is produced is followed by a global perspective of other countries' disposal programs. The program for permanent disposal of high level nuclear waste in the United States is then examined in detail

from technical, legal, political and economic perspectives. The most space is devoted to the issue's politics as this, rather than the technical questions, seems to be the critical component of any proposed solution. Finally, a comparison of the program for permanent waste disposal with the U.S. program for temporary disposal is offered (the "Monitored Retrievable Storage" facility). Conclusions from the research detail several important implications for the country's energy and economic futures from this significant, national-level issue.

HIGH LEVEL NUCLEAR WASTE GENERATION

The manufacture, operation and refueling of nuclear reactors and the processing of uranium and plutonium for nuclear weapons construction generates materials which are, to varying degrees, radioactively contaminated. These contaminated items include both liquids and solids of wide diversity. In general, the radioactive byproducts of working with nuclear reactor or weapons components (anti-contamination suits, gloves, boots, absorbents, plastic sheeting, etc.) are termed either "low level" radioactive waste if their radiation levels are relative mild, and their radioactive "half-life" (the time it takes for half of an element or isotope's radioactivity to decay away) is short (several years at most); "transuranic waste" if the source of radioactivity was uranium or associated elements (plutonium, for example); or "high level" radioactive waste.

High level radioactive waste (HLW), is generated when nuclear reactors (commercial or military) are refueled (spent reactor fuel rods contain a number of radioactive isotopes -- about 10,000 years is the period required for over 99 per cent to decay to stable, non-radioactive form). HLW produces both high radiation levels and some heat. In the beginning of the commercial nuclear power program, when storage of spent fuel on the reactor plant sites was expected to be required for only a few years, the rods were stored in pools of cooling water. As a permanent disposal solution could not be decided upon, inventories of spent fuel built up at the various nuclear power plants. First, the spent fuel rods were packed closer together (a solution termed "re-racking"). More recently, the use of containers that rely on passive cooling ("dry casks") has been approved by the Nuclear Regulatory Commission to alleviate the power plants on-site storage dilemma.

THE NUCLEAR WASTE POLICY ACT OF 1982

Peaceful nuclear energy was placed in service in the 1950's with no detailed plan for long term disposition of its radioactive waste. There were ideas, to be sure, including sea bed burial, and sending it into outer space via rocket. However, despite well-intentioned planning and research efforts, this country's first generation of commercial nuclear power plants and naval reactors underwent numerous refueling operations without a plan for the ultimate disposal of the

long-lived HLW they generated.

In 1957 the National Academy of Sciences first recommended deep "geologic disposal" (burying the waste in stable rock deep below the surface of the earth).[2] In the 1960's preliminary investigations of salt beds as repository sites was begun.[3] It was not until 1976, however, that the first federal program to collect data on potential repository sites was established.[4] As Christopher W. Myers of the RAND Corporation writes,[5]

> "In the early years of nuclear power development, it had been widely assumed that the technical issues affecting radioactive waste disposal were easily resolvable and that adequate disposal capacity would become available by the 1970's when it would be needed."

In 1982, the first legislation aimed at setting national policy concerning high-level nuclear waste disposal was introduced in Congress. Signed into law on January 7, 1983, and amended on December 22, 1987, the Nuclear Waste Policy Act (NWPA) of 1982 was a major milestone in the nation's management of high-level nuclear waste. The NWPA specified:[6]

(1) A national policy for storing, transporting and disposing of spent nuclear fuel and HLW, including a requirement for public participation in states or Indian reservations considered as candidates for repository siting.

(2) Establishment of the "Office of Civilian Radioactive Waste Management"(OCRWM) within the U.S. Department of Energy (DOE) to implement the policy and to "develop, manage and

operate a safe waste management system to protect public health and environment."

(3) DOE responsibility for siting, construction and operation of a deep, mined geologic repository, to begin operations no later than 31 January 1998.

(4) DOE responsibility for construction and operation of a Monitored Retrievable Storage (MRS) facility.

(5) DOE responsibility for transporting the waste to a repository and an MRS facility.

(6) Establishment of the Nuclear Waste Fund, designed to cause the consumers of electricity generated by nuclear power to pay for the government's costs of developing the disposal system and disposing of the HLW (costs of placing defense HLW in the repository will be borne by all taxpayers).

(7) Establishment of a Nuclear Waste Technical Review Board to evaluate the validity of DOE activities in geologic site characterization and packaging/transporting spent fuel. The 11-member board, nominated by the National Academy of Sciences, and approved by the President, must report to both Congress and DOE at least twice a year until disposal begins in a permanent repository.

The implementation of the above provisions since their enactment has not proceeded smoothly or according to schedule. Before we take a detailed look at how long term HLW disposal has progressed in the United States, however, it is instructive to establish a point of reference for comparison. The

following section summarizes efforts underway in the rest of the world to cope with the issues surrounding HLW disposal.

GLOBAL HLW DISPOSAL PROGRAMS

As of 1990, an estimated 84,000 metric tons of spent fuel from the world's 413 commercial nuclear power plants had accumulated, all of it in some form of temporary storage awaiting final disposition.[7] Table 1 shows the distribution by country of the world's spent fuel portion of HLW.[8]

Table 1: Accumulation of Spent Fuel from Commercial Nuclear Plants, 1985, 1990 & 2000 (projected). (amounts shown are in metric tons)

Country	1985	1990	2000
U.S.	12,601	21,800	40,400
Canada	9,121	17,700	33,900
Russia/CIS	3,700	9,000	30,000
France	2,900	7,300	20,000
Japan	3,600	7,500	18,000
Germany	1,800	3,800	8,950
Sweden	1,330	2,360	5,100
U.K./Other	5,939	14,540	36,715
Total	40,991	84,000	193,065

It is of note that the 1990 total in Table 1 is over twice the 1985 value, and another doubling is projected before the turn of the century. The International Atomic Energy Agency (IAEA) forecasts that by the middle of the next century, when

all nuclear reactors now operating have been shut down (note their assumption that present trends imply the demise of the commercial nuclear power industry), the worldwide inventory of spent nuclear fuel will exceed 450,000 metric tons.[9]

Foreign governments engaged in nuclear waste generating operations have pursued long term disposal programs that are basically similar to the Department of Energy's NWPA-dictated program, with one significant exception: reprocessing.

The reprocessing of spent fuel prior to HLW disposal is conducted by France, India, Japan, the Commonwealth of Independent States (CIS) and the United Kingdom.[10] The technology, essentially a complicated chemical process, was originally developed to extract the fission byproduct plutonium. Its chief advantages are that it in effect recycles radioactive materials, reusing plutonium and uranium that have not fissioned (their atoms split) yet; and, it places the spent reactor fuel in a safer, stabler condition. In the optimistic days of the 1950's, when nuclear energy was expected to free Man from reliance on fossil fuels, it was envisioned that the plutonium extracted from the reprocessing of spent fuel rods would be used to build "breeder reactors" (as well as nuclear weapons). A breeder reactor is a nuclear reactor fueled with plutonium that "breeds" more plutonium fuel as a byproduct of its operations, a veritable perpetual motion machine. The breeder reactor represented the leading edge of nuclear technology until the early 1970's when environmental and cost

concerns began the unraveling of the industry.

Since the Three Mile Island accident the waning of the "nuclear option" for generating commercial electricity has accelerated and plans for breeder reactors have been basically shelved. The only major breeder reactor plant in commercial operation is the French 1200 megawatt Superphenix plant (and its poor reliability makes it a candidate for shutdown at any time).[11] The result of this is that the countries which include reprocessing in their nuclear waste programs end up with plutonium which they have little use for (assuming they don't desire it for a nuclear weapons program).

Another disadvantage of reprocessing is that it actually increases the volume of intermediate and low level waste requiring disposal. According to the British Central Electricity Generating Board, reprocessing expands the volume of radioactive waste 160-fold.[12]

Despite these negative factors, both France and the U.K. have included reprocessing of spent nuclear fuel in their long term disposal programs. In fact, both countries accept shipments of spent fuel from the rest of the world and provide reprocessing services, returning the HLW in "vitrified" (solidified in glass) form for ultimate disposal by the countries of the fuel's origin.[13]

Reprocessing enhances the stability of the waste before it is disposed of and is a promising alternative to the U.S. philosophy. Ultimately, all of the countries engaged in

reprocessing plan "deep geologic disposal" as a long term solution, and are faced with burying the waste some place. Plans for doing this vary. Some include reprocessing. Some countries (U.K., Netherlands) are exploring a sea-bed burial option. Table 2 below summarizes HLW disposal plans for countries with significant nuclear power programs:[14]

Table 2: Selected HLW Disposal Plans by Country.

Country	Earliest Start	Status of Program
Canada	2020	Independent commission conducting study of plan for burial in granite; site TBD.
China	none	Spent fuel to be reprocessed; Gobi Desert site under study.
France	2010	Three sites under study; Site selection due in 2006.
Germany	2008	Salt dome site to be studied.
India	2010	Spent fuel to be reprocessed, waste stored 20 years; buried in undetermined site.
Italy	2040	Spent fuel to reprocessed, wasted stored 50-60 years, buried in clay or granite.
Japan	2020	Limited site studies; program with China on underground research facility.
Netherlands	2040	Interim store reprocessing waste 50-100 years then bury in sea-bed/another country.
Russia/CIS	none	Eight sites under study for

		deep geologic disposal.
Sweden	2020	Granite site to be selected, 1997; site characterization study started.
Switzerland	2020	Burial in granite or sedimentary formation at TBD site.
United States	2010	Yucca Mountain, Nevada, site to be studied and if approved receive 70,000 tons HLW.
United Kingdom	2030	50 year storage approved, 1982; sea-bed burial possible.

PERMANENT HLW DISPOSAL IN THE U.S.

Since the NWPA was signed into law by President Reagan (January 1983), significant changes have occurred in both the selection of where to bury U.S. HLW as well as the schedule for doing same. In 1983, DOE selected nine locations in six states for consideration as potential HLW repository sites. These sites were studied and results reported in 1985. Based on these reports, President Reagan approved three sites for intensive "site characterization" (geologic studies of the areas to determine if features are suitable for isolation of HLW from humans for 10,000 years). The sites chosen were Hanford, Washington; Deaf Smith County, Texas; and Yucca Mountain, Nevada.[15]

In 1987, Congress amended the Nuclear Waste Policy Act and directed DOE to study only Yucca Mountain, an action bitterly opposed by Nevadans including both of their U.S. Senators and

their governor. The 1987 NWPA amendments stressed that if Yucca Mountain was at any time during characterization found to be unsuitable, studies at the site would be stopped and DOE would seek further direction from Congress.

Further schedule slippage occurred in mid-1989 when newly appointed Secretary of Energy, Admiral James D. Watkins, USN (Ret.), a former CNO and nuclear submarine Commanding Officer, directed a comprehensive review of the HLW repository activity schedule. The review concluded that the 2003 activation date could not be achieved (2003 actually represented a slip from the original date, 1998, specified in the NWPA). Another schedule was developed in which repository operations slipped to a 2010 start date.

At present, the achievement of the 2010 commencement of repository operations appears seriously in doubt. Chief among a variety of obstacles the DOE program is contending with are:

-- Geologic issues surrounding site characterization. 16

Three geologic issues of concern at Yucca Mountain are (1) geological uncertainty, (2) water table contamination and (3) mineral resources that could invite future human intrusion.

Despite its remote and desolate location (on the boundary of the Nevada nuclear test site, northwest of Las Vegas) further investigation has revealed that the Yucca Mountain region chosen for the HLW repository has 32 active faults, including one which intersects the proposed location of the underground disposal rooms.

In addition, recent research indicates that what was originally thought to be a tectonically inactive region actually contains a volcanic cone that might have been active as recently as 5 - 10,000 years ago (which is relatively recent in geologic time).

Although the Yucca Mountain site is a desert, a water table has been located below the level of the proposed repository. Concern exists that it could eventually rise and flood the repository. In fact, a DOE geologist wrote an internal memo to this effect in 1987 resulting in public controversy when it was leaked to the press.

Lastly, while no specific mineral deposits are known to exist in the region, the possibility of future exploration for mineral, gas or oil deposits cannot be discounted.

-- Regulatory concerns. The Nuclear Waste Policy Act charges the U.S. Environmental Protection Agency with responsibility for setting standards for acceptable radioactivity releases from the repository. As the EPA had to consider the 10,000 year design life span of the repository, its standards were understandably stringent when first issued, and have been questioned by Mr. John W. Bartlett, Director of the DOE Office of Civilian Radioactive Waste Management: "The (EPA's) performance standards are approximately a million times more stringent than any other radiological standard on earth." 17

In similar fashion, the U.S. Nuclear Regulatory Commission

(NRC), responsible for issuing technical requirements for use in licensing the repository's operations, produced a set of very stringent standards.

Both EPA and NRC standards have been subjects of debate at hearings on Capitol Hill. In Mr. Bartlett's words, "One consequence . . . of the technical realities of meeting the EPA standards and NRC regulations was that the estimated cost to characterize a candidate site rose from an earlier figure of about $100 million to over $1 billion."[18]

-- Problems with management.[19] When DOE slipped the start of repository operations from 1998 to 2003 one of the reasons given was that the original schedule was overly optimistic (a recurring problem with the project caused by underestimation of the power of environmental action groups). When the schedule slipped again, in 1989, to a 2010 startup date, a major reorganization of the DOE Office of Civilian Radioactive Waste Management (OCRWM) was ordered by Admiral Watkins, including nomination of Dr. Bartlett as its full-time Director (succeeding two years of acting Directors). Other actions taken included restructuring lines of reporting in the OCRWM and institution of independent management review.

Despite the new resolve under Admiral Watkins and Dr. Bartlett, the program is faced with political opposition which would challenge any management team.

-- Politics and Litigation. After Nevada was designated as the potential repository site in 1987, its legislature approved a bill (in 1989) prohibiting anyone from storing high level waste in the state. This was contested by the government and eventually appealed to the U.S. Supreme Court where it was overturned. While this litigation was running its course, Nevada Governor Bob Miller attempted to "veto" the siting of the repository in his state. DOE again filed suit, resulting in a decision by the Ninth Circuit Court that the state was not allowed to veto the federal government's repository plan. This case was also appealed through the U.S. Supreme Court which, in March 1991, found in favor of DOE (Nevada v. Watkins).

Later the same month, the U.S. District Court for the District of Nevada heard argument in DOE v. Nevada, an action brought by DOE to compel Nevada to process three permit applications needed to proceed with site characterization. The refusal to issue environmental permits is the latest strategy the state has employed to delay the characterization of the Yucca Mountain repository site.

Nevada has mobilized an array of environmental special interest groups to assist its opposition to the DOE program. Ms. Judy Griekao of Greenpeace in Washington, D.C. summarized the Greenpeace position on HLW disposal as, ". . . opposition to nuclear power, promotion of alternative energy sources, halting production of all radioactive waste, on-site storage of existing waste in retrievable, cannisterized fashion such that

transportation to a burial site is not required."[21] Mr. Marty Haden of the Sierra Club in the District stated that the Club's basic position was opposition to the repository.[22]

Nevada has also contracted a private agency named the Nuclear Waste Task Force to assist in an information campaign against the site.[23] Mr. Frank Clements estimated that, with the help of his organization, 75 - 80 per cent of Nevadans opposed the repository by the close of 1991. The Nuclear Waste Task Force also sponsors public forums and debates on the issue. When asked what the best alternative to the DOE plan was, Mr. Clements referred me to an organization headquartered in Laurel, Maryland called the Institute for Environmental and Energy Research (IEER). Their position calls for removal of DOE from management of HLW disposal with responsibility transferred to an organization without any "vested interest" (referring to DOE's involvement in the promotion of commercial nuclear power over the years). An example of such an organization would be, according to Clements, the National Academy of Sciences.

Nevada opposition forces include broad-based political support. The adversaries include two former governors, the present governor, the state nuclear waste office, the state's second largest newspaper and the congressional delegation led by Senator Richard Bryan.[24] By a clear majority ranging from 60 to 80 per cent, depending on the poll of reference, the Nevada public opposes the repository.[25] The issue is expected to figure

prominently in the next two major election cycles during 1992 and 1994. The governorship, both Senate seats, both congressional seats and the entire state legislature will be contested in these two elections. The politicians have the support of environmental special interest groups and non-profit anti-nuclear research institutes. Their tactics include extensive use of the media, congressional lobbying, vocal opposition to the repository in congressional hearings, legal challenges and bureaucratic roadblocks (the refusal to issue state environmental permits to DOE).

On the side of the federal government are the U.S. nuclear power industry and, possibly, some Nevada business leaders and trade unions (to say these two groups have been low key would be an understatement, however). The U.S. nuclear industry is recently showing signs that it takes the opposition in Nevada seriously. Their strategy includes a significant increase in money spent on advertising in Nevada in an effort to get their side across to the Nevada public. They are attempting to woo the state's congressional delegation, also, but with little apparent success.[26]

Each side can point to some successes. The Nevada coalition has achieved significant delays in the site characterization work at Yucca through use of the political and legal systems. Its ability to muster support for its position has been particularly impressive. Political party affiliations

have been set aside. Consensus between politicians, scientists, engineers and environmental special interest groups has been attained and maintained. Significant amounts of money to support media advertising campaigns and legal challenges have been raised. Their combative attitude is apparent in the following statement of Nevada governor Miller: "We're determined to keep kicking, scratching and clawing for our own survival. That aggravates them."[27]

With U.S. Supreme Court decisions in their favor, the government has obtained permission to begin the characterization work and the first phase began in January 1992. The studies are scheduled to take 7 - 10 years. If the site is determined suitable, the Energy Secretary will recommend the site to the President. Nevada can veto the site selection but the NWPA gives Congress the option of overturning Nevada's veto. If the site is finally designated to be Yucca Mountain, it must then be licensed by the Nuclear Regulatory Commission prior to construction, operation and final closure.[28] Clearly, even 2010 (the present date for commencing repository operations) is optimistic, in view of the tremendous political opposition to the project.

The political debate over Yucca Mountain is being conducted at an emotionally-charged level which tends to obscure scientific reason. One charge common in the Nevada press has been that U.S. Senator J. Bennett Johnston (D.-Louisiana), the primary architect of the 1987 NWPA

Amendments Act, colloded with DOE to ensure Yucca Mountain was designated as the country's first HLW repository. Termed the "Screw Nevada Bill" throughout the state,[29] the 1987 Act terminated the consideration of the three sites previously under consideration (in Hanford, Wa.; Deaf Smith Cty., Tex.; and Yucca). Mr. Frank Clements of the Las Vegas-based Nuclear Waste Task Force told me in an interview that he thought Senator Johnston had made a deal with then-President Reagan prior to 1987 -- at the time DOE was considering salt dome regions of Louisiana as a potential repository site. Clements charges that Reagan told Johnston that if Louisiana would accept the strategic petroleum reserve on Louisiana soil he would "not have to worry about nuclear waste."[30]

The Las Vegas Review-Journal charges that Johnston, Chairman of the Senate Committee on Energy and Natural Resources, receives almost ten per cent of his Political Action Committee (PAC) reelection campaign contributions from nuclear energy related PAC's (since 1985, the total exceeds $137,750). The Review-Journal states that Johnston's collusion with DOE is indicated by the fact that DOE Sec. Watkins campaigned in Louisiana on behalf of Johnston during the 1990 challenge from former Ku Klux Klansman David Duke.[31] Nevada Senator Harry Reid was quoted in 1988 to say, "I think Bennett Johnston has worked with the Department of Energy to jam the nuclear waste dump down the state of Nevada's throat."[32] Openly an advocate of nuclear energy, Johnston has said,[33]

> "If I were a Nevadan living in the real world, I would be happy with (the NWPA Amendments Act of 1987) . . . I would bet that in a very few years Nevada will deem this one of their most treasured industries."

The allegations concerning Senator Johnston and the "Screw Nevada Bill" are a classic example of "Not-in-my-backyard" ("NIMBY") politics. The syndrome has prevailed for decades, whether the issue was halfway houses for recovering drug addicts, landfill sites, hazardous waste disposal or nuclear waste repositories. The sacrifice of logic and reason for resentment, fear and intransigence has typified the fights.

Charles Piller wrote in a recent New York Times editorial that, in the minds of the government and the nuclear industry, "Fear and selfishness . . . lead communities to bitterly resist any new or potentially dangerous technology, regardless of merit, that poses even small risks."[34] In the opinion of many, the HLW repository siting is not a technological issue (despite significant technical issues, outlined previously). As an example of how the technical is obscured by the politics in the NIMBY syndrome, Sen. Bennett Johnston is quoted again, this excerpt taken from a hearing he chaired on March 21, 1991 concerning the Yucca Mountain repository:[35]

> "Storage and disposal of nuclear waste is not a technical problem. It is a political problem and an emotional problem. It is a problem that boils down to two very simple facts. Nuclear waste must be disposed of somewhere but no one wants it in his or her State.
>
> "We have been around this block many times

> before. We have heard from States that they do not want nuclear waste in their backyard. We have heard from the Department of Energy that it must go somewhere. We have heard from the utilities that it is already in storage on site at nuclear reactors all around the country.
>
> "The simple fact is that nuclear waste is already in temporary storage in 33 States around the country. When Congress amended the Nuclear Waste Policy Act in 1987, the Department of Energy was directed to conduct site characterizations and testing at the Yucca Mountain site in Nevada. . . . Unfortunately, more than 3 years later, we have not even begun that testing program."

-- Scientific Uncertainty. The contentious politics that have surrounded the HLW disposal issue tend to obscure the scientific and technical issues involved. In the present climate in which complicated problems must of necessity be condensed to a format suitable for the evening news or CNN, the strong tendency of the media is to play up the politics and provide less air time to the science behind the political scene (given the average American's poor understanding of science, this is astute strategy). This has certainly been the case with Yucca Mountain -- and as a result, what represents arguably one of the most difficult scientific and engineering endeavors attempted in history has been turned into a political exercise in choosing up sides. The problem is, the factions that have assembled are largely uninformed about their cause.

The government relies on scientific advice from the National Research Council, whose members are drawn from the National Academy of Sciences, the National Academy of

Engineering and the Institute of Medicine. In July, 1988, the National Research Council's Board on Radioactive Waste Management sponsored a retreat in Santa Barbara where experts from around the world joined the Board in intensive discussions of the U.S. policies and programs for HLW disposal. The issue of the scientific uncertainty involved in designing something to perform for 10,000 years was a central theme in their report of the conference proceedings. Specifically, the Board said that, in response to political pressures, the DOE program was too rigid to deal with the significant uncertainty associated with engineering the repository facility. Quoting from the Board's report, "Rethinking High-Level Radioactive Waste Disposal":[36]

> "Those involved in HLW management must also avoid the trap of promising to reduce uncertainties to levels that are unattainable. Uncertainties are certain to persist. Whether the uncertainties in geologic disposal are too great to allow proceeding can only be judged in comparison to the projected risks and uncertainties for the alternatives, such as delayed implementation of disposal or surface storage of spent fuel. As a rule, the values determined from models should only be used for comparative purposes. Confidence in the disposal techniques must come from a combination of remoteness, engineering design, mathematical modeling, performance assessment, natural analogues, and the possibility of remedial action in the event of unforeseen events."

The above excerpt represents the main deficiency the Board on Radioactive Waste Management found with the DOE approach to long term HLW disposal. Their report speaks of the dangers of

being "too rigid" in the following excerpt from their report's abstract:[37]

> "This approach (DOE's HLW disposal program) is poorly matched to the technical task at hand. It assumes that the properties and future behavior of a geological repository can be determined and specified with a very high degree of certainty. In reality, however, the inherent variability of the geological environment will necessitate frequent changes in the specifications, with resultant delays, frustration and loss of public confidence. The current program is not sufficiently flexible or exploratory to accommodate such changes."

This, then, appears to be one of the key issues -- do we really need to dispose of HLW "as soon as possible," driven by strict schedules and closely managed milestones? What is the sense of urgency that has resulted in the federal government and a state becoming so locked in battle that images of "State's Rights" disputes from the Civil War era are conjured up? Don't we have enough time to fully satisfy the public that the government knows exactly what it is doing, instead of settling for what appears to be a case of Washington forcing a state to accept the entire country's high level radioactive waste while its aggravated and disillusioned populace objects?

To answer the first part, when the Nuclear Waste Policy Act was first envisioned, a sense of urgency with respect to spent fuel building up at commercial nuclear power plants was a concern. Since 1983, however, some actions have been taken to alleviate this concern (the re-racking and dry cask storage alluded to previously). The NRC began licensing dry cask

storage schemes at the commercial nuclear sites in the 1980's and states that they are safe for 100 years worth of storage.[38] So the issue of the sites running out of storage space is effectively dead. There is not the sense of urgency, at least from a logistic viewpoint, that there appears to be.

There are economic and political reasons the government and the nuclear industry would like to see a permanent solution to HLW disposal, however. Not the least of these is the thought that future development of nuclear power depends very much on the country coming to grips with the issue such that the solution is not only technically sound but acceptable to the major factions involved.

-- Economic considerations. What to do with the country's nuclear waste has dogged politicians and the nuclear industry for practically an entire generation now. During that time there have been occasional successes. One of the successful policies with respect to nuclear waste, from an economic standpoint, has been the Nuclear Waste Fund.

The Nuclear Waste Fund was established by the NWPA of 1982 to provide financing for the actions mandated by that legislation -- specifically, the siting, design, construction and operation of deep, geologic repositories for the permanent disposal of spent nuclear fuel and high-level radioactive waste.[39] Fund-raising is accomplished by all nuclear utilities paying a 1 mill (one-tenth of a cent) per kilowatt-hour fee for electricity sold to the public.[40] Collection of fees began

April 7, 1983 and continue today. The intent of the Nuclear Waste Fund provisions of the NWPA was that the Fund would function on a "full cost recovery basis," that is, the government's costs for developing the HLW disposal facility would be fully funded by the generators and owners of HLW. As of March 31, 1990 the Nuclear Waste Fund had collected approximately $4.4 billion from fees and had accrued $0.7 billion from investment activities. This compared favorably at that time with DOE's HLW disposal program costs which were $2.5 billion then.[41]

Another positive statistic is that the projected net balance in the Nuclear Waste Fund (after disbursements for HLW disposal) showed a surplus every year since 1984, rising at an annual rate of $0.4 billion per year. Of course, the counter-argument to this is that the HLW disposal program went essentially nowhere in that period, existing only on paper and not getting permission to turn over a shovel full of dirt at the Yucca Mountain site.

The Nuclear Waste Fund cuts down on the size of the portion of the DOE budget designated for HLW disposal. In Fiscal Year 1992, DOE requested $305.1 million for the Office of Civilian Radioactive Waste Management activities not covered by the Nuclear Waste Fund.[42]

It is fortunate that Congress had the foresight to legislate funding of HLW disposal through utility fees; nevertheless, the political stalemate between Nevada and DOE

has resulted in billions of dollars being spent on excruciatingly slow project progress. Senator J. Bennett Johnston (D.,La.) summed it up at a recent hearing on the DOE FY 92 Budget before his Senate Appropriations Subcommittee:[43]

> ". . . as I look at nuclear waste, for example, we have spent enormous amounts of money and we still do not have nuclear waste in the ground. . . . So I am frustrated about this, the potential for waste -- and I am not talking about nuclear waste, I am talking about money waste -- (the amount) is so enormous in these fields. It just absolutely boggles the mind."

The amounts that have been spent on disposal of spent fuel are actually relatively small in comparison to other radioactive material cleanup projects. It is probably those projects that Senator Johnston was thinking of in the above quote -- for example, the cleanup of the radioactive waste (most of it plutonium related) at the country's nuclear weapons manufacturing facilities is expected to reach $180 billion before completed, rivaling the Savings and Loan bailout in cost.

Ultimately, though, the short term economics of HLW and other radioactive material disposal programs have been only a part of the focus in Congress and DOE. The larger question, one which will play a pivitol role in this country's long term economic growth, is what fraction of the nation's electric power generation in the next century can reasonably expected to be produced by nuclear means. This is an economic

consideration from the standpoint that plans must be made now, in the 1990's, to assure sufficient generating capacity is constructed, tested, licensed and on-line when needed next century. If there is to be a continuation of the "nuclear option," the problem of nuclear waste must be addressed to the public's satisfaction (including environmentalists and NIMBY activists). Otherwise, the fact that the nuclear industry is waiting in the wings with brand new "advanced light water nuclear reactor" designs is of little significance. The political coalitions that stopped the Long Island Shoreham plant, that have slowed down the characterization work at Yucca Mountain, and who have pledged to keep fighting until all nuclear plants in the country are shutdown, can be expected to continue their efforts, with important implications for the future of nuclear energy. These are some of the difficult circumstances the President's National Energy Strategy will have to address as it works its way through Congress this Spring.

INTERIM HLW DISPOSAL AND THE MONITORED RETRIEVABLE STORAGE (MRS) FACILITY.

If any optimism that the HLW disposal questions summarized in this paper exists, it may possibly be located in the procedures being followed to locate an interim disposal

facility, a brief summary of which follows.

In 1985, DOE concluded that an MRS facility could "enhance the overall waste management system."[44] In March 1987, DOE submitted a proposal to the Congress for construction of an MRS facility at a site in Oak Ridge, Tennessee. Congress responded in December with the passage of the NWPA Amendments Act of 1987 which included a requirement for the establishment of the Office of "Nuclear Waste Negotiator," whose job was to find a state or Indian tribe willing to host a repository or an MRS facility (the bill annulled the Oak Ridge proposal).

The use of a Negotiator to find a state or Indian tribe to volunteer for the MRS site is a significant difference from the confrontational tactics that have evolved with Yucca Mountain. In late 1990 Mr. David H. Leroy was confirmed by the U.S. Senate as Nuclear Waste Negotiator. By December 1991 two applications for $100,000 DOE grants to, "gain an understanding of the nation's nuclear waste management system, including the MRS . . . and determine whether it (the applicant) has an interest in pursuing further feasibility studies" had been issued.[45] The two applicants were the Mescalero Apache tribe of Mescalero, New Mexico and Grant County, North Dakota.

The basic MRS facility concept envisions a temporary HLW storage site with the capability to receive HLW, store it and stage it for transportation to the permanent repository. The original Oak Ridge location was chosen because 90 per cent of all HLW is stored at commercial reactor sites in the eastern

United States. As transportation of HLW is a particular concern, siting it in the East made sense. Tennessee, and the Government Accounting Office, raised various questions and objections, however, resulting in Congress stipulating that the MRS facility site would be determined through the creation of the Nuclear Waste Negotiator. This may turn out to be a good idea on the part of the Congress if it reduces the polarization and power struggles seen in the Yucca Mountain program.

DOE strongly supports establishment and operation of an MRS facility for several reasons. First, the MRS would ensure that, ". . . the burden of uncertainty about repository startup and operation would be borne primarily by the Federal waste-management system rather than the utilities."[46] Second, it is expected that operation of an MRS facility will in essence give the federal waste management system a trial run -- and much needed experience in accepting, transporting and handling large quantities of HLW, thus increasing the likelihood of timely and reliable operation of the permanent repository. Maybe most important, establishment of an MRS facility would give the overall program much needed flexibility. By law, DOE is scheduled to become the "owner" of all the country's spent commercial reactor fuel by 31 January 1998. Thus, the question of whether the permanent repository becomes operational by 2010 could become much less of an issue.

In light of the serious delays being experienced with the Yucca Mountain site, one can envision a scenario in which the

"interim" MRS facility becomes a de facto permanent repository. The NWPA Amendments Act of 1987 envisioned this and contained provisions to guard against its occurring -- it specified that the Secretary of Energy could not select an MRS site until he had first recommended a permanent repository site to the President. Also, construction of an MRS site could not begin until the NRC had issued a construction license for the permanent repository. Last, construction of an MRS facility was prohibited if the permenent repository license was revoked or construction of the repository ceased. These three provisions link the the MRS facility and the permanent repository scheules.[47] As this paper is written, OCRWM was supporting a section of the National Energy Strategy Bill which would remove the linkage between repository and MRS so that plans for the MRS could proceed. In view of the chronic delays at Yucca Mountain, this is required if DOE is to meet the mandated January 1998 deadline for acceptance of spent fuel at an MRS facility (without further amendments to the NWPA).[48]

Another issue related to the MRS facility is whether or not an attempt to reduce the volume of the spent fuel prior to permanent disposal should be made. As was noted earlier, the U.S. does not plan to conduct spent fuel reprocessing in the future. The shutdown of reprocessing in the country due to nuclear proliferation concerns has never been rescinded. Thus, the question is, how much space in a repository can be saved by innovative packaging and consolidation prior to permanent

disposal? At present, there is no consensus at DOE on this issue.

In summary, then there is cause for encouragement in the politics and policies being pursued with the Monitored Retrievable Storage facility. The main unresolved issue is whether the NWPA will be amended (again) to "de-link" the MRS from the Yucca Mountain schedule. This seems appropriate in view of the significant schedule delays incurred at Yucca since the 1987 amended NWPA tied the two together. It could also be that the more serene political climate surrounding the MRS facility provides some insight into how the government might de-escalate the confrontation over the permanent repository.

CONCLUSIONS

The U.S. government's effectiveness in achieving a solution to the country's high level radioactive waste disposal problem will have profound effects on both near term and long run policy and societal objectives. It is clear that the present adversarial climate surrounding the issue has produced delays and disruptions in the DOE's schedule for activating a permanent geologic disposal facility. Acerbic debate in both chambers on Capitol Hill, extensive litigation that has run several times through the entire court system including the U.S. Supreme Court, and significant added costs borne by taxpayers and utility ratepayers have characterized the fight.

It appears that unless significant changes in the Yucca Mountain political atmosphere are effected, a result of the HLW disposal project in Nevada could be the permanent alienation of the state's populace.

One of the central policy questions seems to be whether the government should continue on its present course or attempt to find an alternate solution that is more politically acceptable. The recent creation of the Nuclear Waste Negotiator position, responsible for soliciting states or Indian tribes to volunteer for the geologic repository or the Monitored Retrievable Storage (MRS) facility to be situated on their territory, is a step in the right direction. If the

Negotiator is unsuccessful in finding a volunteer for the permanent repository, the following additional alternatives to Yucca Mountain have been variously proposed:

-- Secure, monitored storage of the waste at the commercial/government reactor sites. This is the option most environmental action groups favor. Implicit is the eventual phasing out of all nuclear-generated electric power, a position the government and the nuclear power industry do not share.

-- Monitored storage in a central facility awaiting technological advances that could provide a more acceptable permanent solution. The technology advance some communities hope for is a process known as "transmutation" whereby long-lived HLW would be transformed into relatively short-lived isotopes using bombardment of the materials with sub-atomic particles from a particle accelerator. This technology does not exist today, even in experimental form. There is little consensus on whether it will ever be realized.

-- Sea-bed disposal. Some groups favor encapsulating the waste and dropping it into soft seafloor sediments that exist in various ocean regions, many of which are very deep (over 18,000 feet). The sediments are geologically stable and the waste could be expected to sink initially and then be steadily covered by further sedimentation over time. The chief issue that has been raised with sea-bed disposal is that international law may cause a worldwide political stalemate similar to that seen in Nevada. One can imagine the difficulty

involved in achieving world consensus on radioactive waste disposal.

-- Find a geologic repository that is acceptable to a majority of Americans including those living in its vicinity. Most Americans probably see little wrong with storing the country's HLW in Nevada's Yucca Mountain. Nevadans want it anywhere but their "backyard." The debate is becoming increasingly time and resource consuming. Worse, the polarized views of the opposing sides could begin to cloud the government's vision affecting its ability to deal rationally with what is a major issue of our time. What to do if the Nuclear Waste Negotiator fails to obtain a volunteer for the permanent repository, and political status quo is maintained, is the question. A component of this is resolution of the outstanding technical questions that have surfaced since work at the Yucca Mountain site commenced.

One of the key parts of the debate centers on the future of nuclear generated electricity with its associated risks and benefits. Does its significant potential contribution to the nation's economic growth outweigh its hazards? If so, what needs to be done to convince a majority of Americans of this such that progress toward expansion of the industry can begin again? It should be noted that fusion reactors, expected to be capable of producing power commercially by about 2040, will also be radioactive waste generators (although not to the levels seen in fission reactors). Thus, solving radioactive

waste disposal issues is mandatory for fusion, even if fission reactors are phased out in its favor.

In summary, the HLW disposal issue is national in scope, but must be addressed with plans that are regionally as well as nationally acceptable. A solution that will provide significant economic incentives to the region accepting the repository, as well as meeting the strictest technical and safety standards, is needed. Achievement of this sort of solution will require much additional time and effort by the country's best minds. It is clear from the present battle over the Yucca Mountain site that the present solution is flawed at least from a political standpoint, if not a technical one. A "win-win" resolution in which all sides agree on the government's plans and can expect to be rewarded by them seems to be the vision that policy makers should be working toward.

The United States' position as world leader in so many areas applies to radioactive waste disposal as well. No other country is as far along as we are in finding a permanent solution. While the problem may not be an "imminent" crisis, we have delayed solving it for too long (nearly half a century) already. Our solution needs to be one we can point to for centuries to come as a model for future generations in its technical and scientific soundness, its engineering safety margin and the leadership resolve that achieved the correct answer despite the politics of the time.

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